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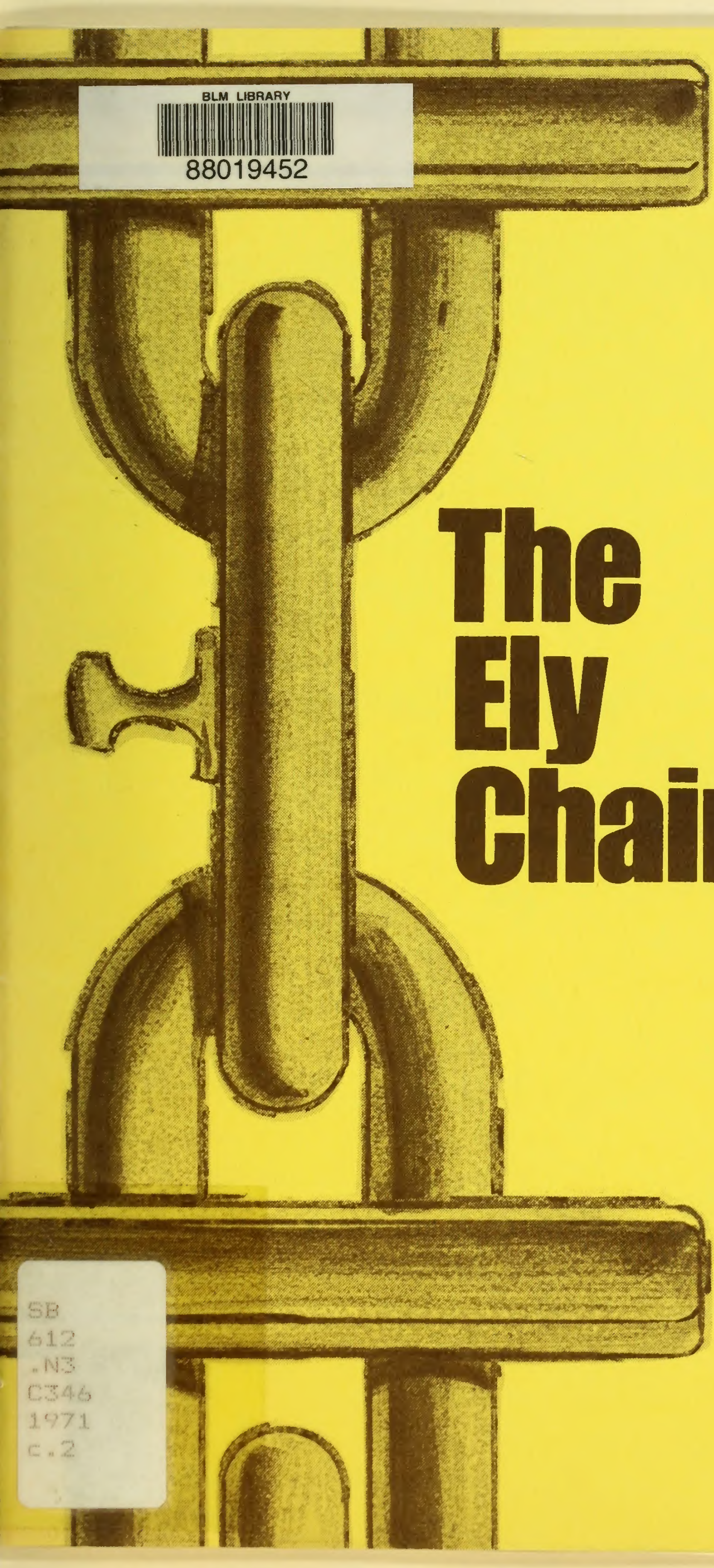

The Ely Chain

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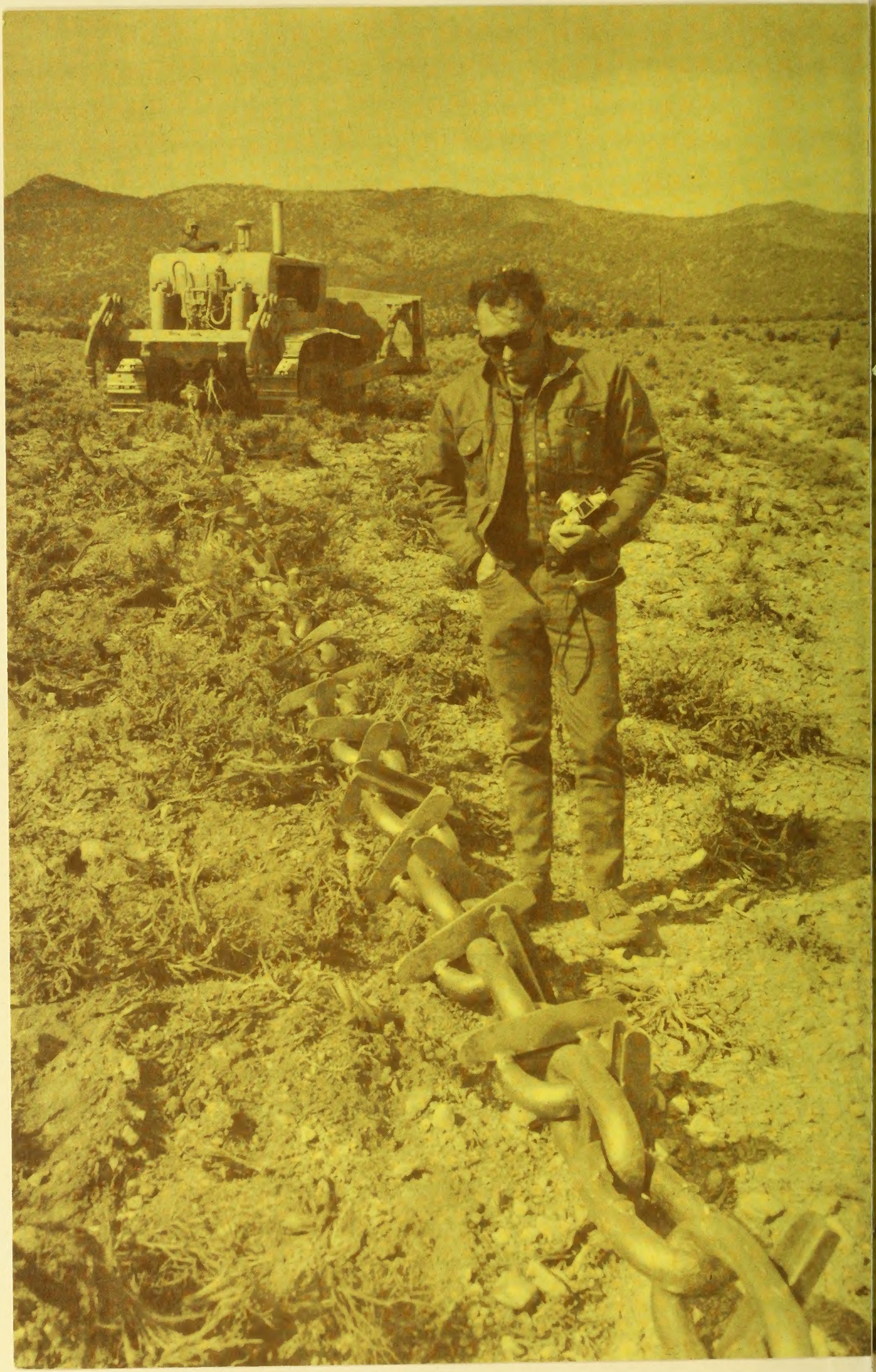

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The Ely Chain

A practical handbook of principles and practices of chaining and vegetative manipulation

by
Don Cain,
Wildlife Management Biologist

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1971
U. S. DEPARTMENT OF THE INTERIOR
Bureau of Land Management
Ely, Nevada

ABSTRACT

The Ely Chain is a vegetative manipulation technique. The objective is to decrease less desirable plants and increase desirable species. This report documents the basic principles and practices of the technique. Discussions are provided regarding relative factors such as planting methods, planning for aesthetical values, protection of seedlings from animal damage, livestock management, and other points of interest.

Inspecting the Ely Chain on a sagebrush rehabilitation project near Ely, Nevada

ACKNOWLEDGEMENTS

The author gratefully acknowledges the following workers who contributed to the development of the Ely chain: Marvin H. Hammersmark; Larry A. Doughty, Lakeview District Office; and members of the Anchor Chain Subcommittee. A. Perry Plummer, Intermountain Forest and Range Experiment Station, is acknowledged for his observations and helpful suggestions extended during the past four years. Doyle Kline, New Mexico State Office; Rich Aro, Colorado State University; and personnel in the Nevada State Office and Portland Service Center are acknowledged for their review of the manuscript. Finally, special thanks are given to Jim Yoakum, Nevada State Office, for his ever-present support in making this publication possible.

Thanks go to the Caterpillar Tractor Company, Peoria, Illinois, for their interest in the Ely chain, which led to the inclusion of the Ely chain in the movie entitled "Bring Back The Grass."

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Introduction

During the past two decades, anchor chaining has been used widely in range restoration work to reduce competition from pinyon-juniper and certain shrub species. It is favored because of its low cost and adaptability to areas with steep terrain and soils too rocky to permit use of other mechanical methods.

The common practice involves a combination of anchor chaining with a smooth anchor chain, followed by the aerial application of seed of desirable plant species, then a second chaining to cover the seed and enhance removal of undesirable plants.

Results of this practice have been varied. In many areas, successful range restoration has been accomplished. In Nevada, the technique has not always produced desirable results. In these cases there have been poor elimination of competition, inadequate seedbed preparation and poor seed coverage. As a consequence, anchor chaining has been looked upon as an ineffective means of restoring Nevada rangelands.

In 1966, the Bureau of Land Management in eastern Nevada, in connection with the Anchor Chain Subcommittee of the Range Seeding and Equipment Committee initiated a four-year project to improve the usefulness of the anchor chain in restoring depleted rangelands covered by pinyon-juniper and big sagebrush. As a result of this effort, the Ely chain was developed, tested and evaluated under field conditions. In connection with this project, attention was paid to the role of anchor chaining in range restoration work, mixture seedings, aesthetics and selected other subjects.

The purpose of this handbook is to present the results of this work. It is hoped the Ely chain can be used successfully as a "multiple-use tool" where ordinary anchor chains have failed.

Part I

Ely Chain, Design Construction and Use

The Ely chain is probably the simplest of all mechanical tools used in range restoration work. It is simply a large anchor chain with short lengths of railroad iron welded across each link (Fig. 1). The unique characteristic of the Ely chain lies in the rooting and scarifying action of the rail as the chain rolls in the direction of pull. The rolling action is facilitated by the use of large anchor chain swivels attached to each end of the chain. Considerable work has been devoted to chain swivel design, construction and use. The following guidelines are the result of that work and are intended to aid those desiring to build and use an Ely chain.

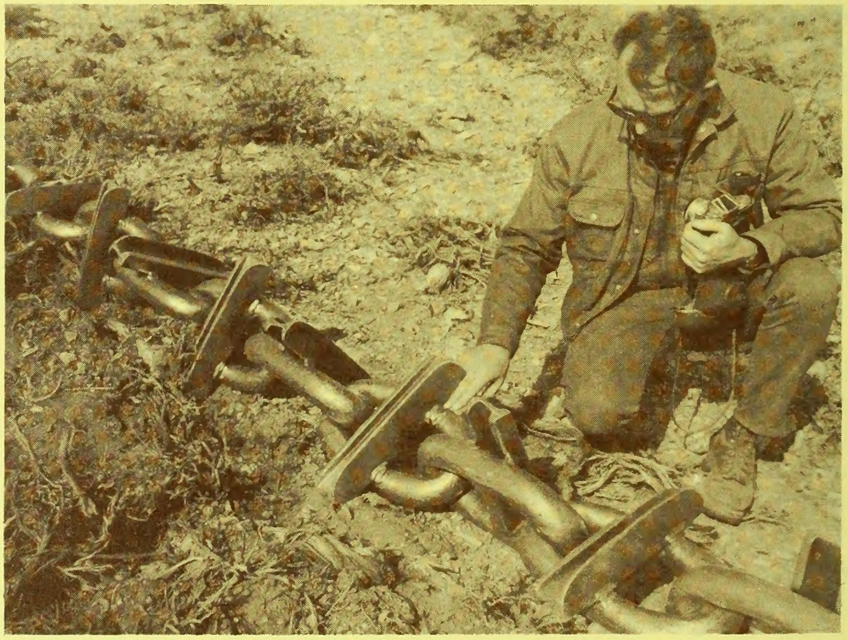

FIGURE 1 — A large anchor chain with short lengths of railroad iron welded across each link.

SIZE OF ANCHOR CHAINS

Anchor chains of ten different sizes (weights) are available from Naval Surplus Depots (Table 1).

These can usually be procured for the cost of transportation. Actually, any size can be modified into an Ely chain. However, experience has shown that the most effective and useful Ely chains are made from the heavier chains weighing from 62 to 110 pounds per link. Lighter chains, 40 pounds per link, have been made into satisfactory Ely chains which are suitable for use under certain conditions.

TABLE 1 — Size of anchor chains available as naval surplus property.

LINK DIAMETER (INCHES)	LINK LENGTH (INCHES)	LINK WIDTH (INCHES)	WT/ FT. (LBS.)	WT/90' LENGTHS (LBS.)	NO. LINKS/ 90' LENGTHS	BREAK TEST (LBS.)
1-1/2	9	5-1/2	23	2035	179	131,000
1-3/4	10-1/2	6-1/4	30	2720	153	172,000
2	12	7-1/4	40	3525	133	225,000
2-1/4	13-1/2	8-1/4	50	4450	119	285,000
2-1/2	14	9	62	5528	107	352,000
2-3/4	16-1/2	10	75	6725	97	405,000
3	18	11	90	8035	89	457,000
3-1/4	19-1/4	11	110	--	85	-----

RAIL

Railroad iron has proved to be the most satisfactory and easily obtainable material for use as rail, and is available in 40, 70, 90 and 110 pound per yard weights. In eastern Nevada the rail has been purchased readily from scrap metal dealers and railroad companies.

Any size railroad iron can be used as rail. However, the 70 and 90 pound per yard railroad iron is preferred. This is especially important if lighter chains are used; the heavier rail can be used to add weight to the chains.

Experience has shown that a length of rail 18 inches is most effective, regardless of the size of chain used.

The rail can be placed across the anchor chain links in several ways. These include placing the rail on its side, top or bottom. Placing the rail on the bottom gives the advantage of providing the most suitable surface for welding.

Welding is the most practical and economical method of attaching the rail. An assortment of welding material is available. Experience has shown that a

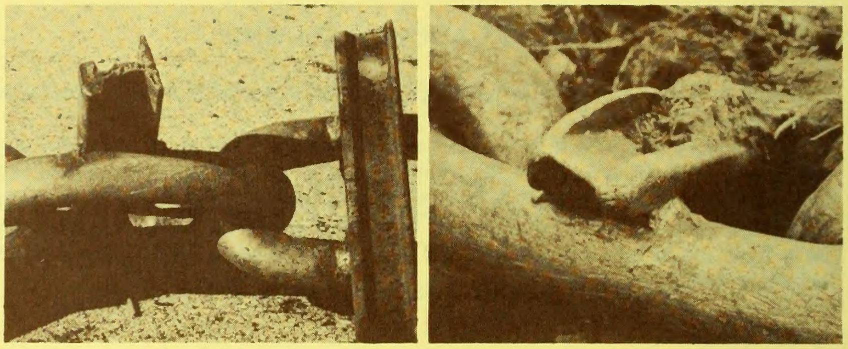

FIGURE 2 — Extreme wear to the ends of the rails occurs without hardsurfacing. (Before and after)

hard alloy material is most effective. Preheating to remove moisture from the chain links aids in reducing embrittlement caused by carburization at the edge of the weld zone. Regardless of the type of rail and welding material used, extreme care must be taken to assure a high quality welding job. Failure to do so will result in separation of the rail from the chain.

Under most field conditions, the ends of the rail are subject to extreme wear, (Fig. 2). The efficiency of the chain is proportionally reduced as the rail wears. This wear can be nearly eliminated by hardsurfacing the ends of the rail. Several types of hardsurfacing material are available, any of which is suitable for use on rail. Hardsurfacing will increase the initial cost of building an Ely chain, but it will significantly reduce maintenance cost.

Welding and hardsurfacing can be simplified by using a fork lift to move and position the anchor chain for easy handling.

ANCHOR CHAIN SWIVELS

Two types of commercially made swivels are available for use on anchor chains. Each has been found to have certain disadvantages. The first type has no bearings, which results in excessive friction, heating and wear (Fig. 3).

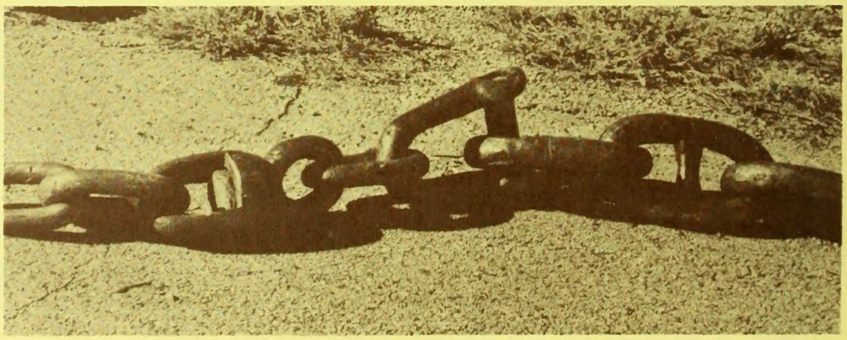

FIGURE 3 — Commercially made swivels with no bearings are available, but they are not suitable for use on the Ely chain.

Even under normal conditions, the life of this swivel is less than three days when used on the Ely chain. The second type features sealed bearings (Fig. 4), but its cost exceeds $1,000.00, making it too expensive.

The most satisfactory and economical swivels yet devised are made from used D-8 or D-9 tractor rollers (Fig. 5). These rollers have sealed bearings and built-in thrust capacity which gives them the capability to withstand extreme stress over large acreage and under difficult conditions. In Nevada for example, swivels made from D-9 track rollers were used to double chain more than 8,000 acres of dense pinyon-juniper without showing appreciable wear.

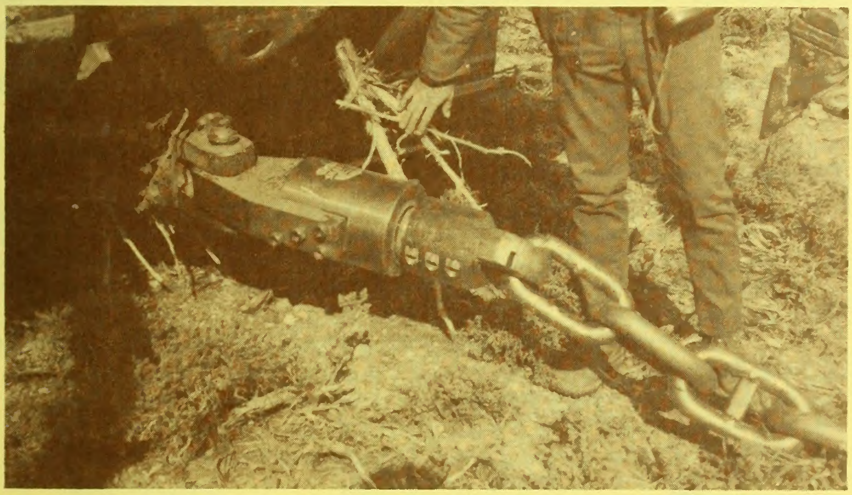

FIGURE 4 — Commercially made swivels featuring sealed bearings are available, but their costs are prohibitive.

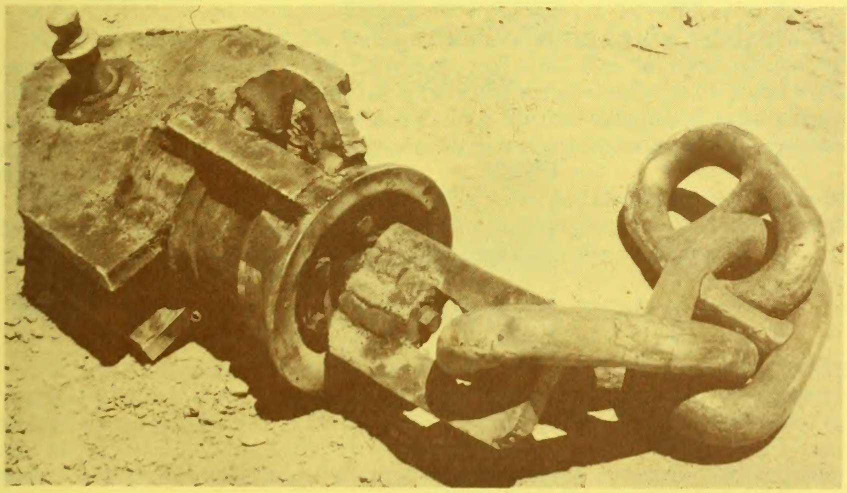

FIGURE 5 — Anchor chain swivel made from a D-9 tractor track roller.

Either size track roller can be modified into anchor chain swivels with a minimum of material and cost (Table 2). The actual cost of acquiring and modifying the track rollers will vary, depending upon available material and labor.

TABLE 2 — Approximate costs of modifying D-8 and D-9 Caterpillar track rollers into anchor chain swivels.

USED TRACK ROLLER	STEEL PLATES	D-7 DRAWBAR PIN	WELDING ROD	LABOR	TOTAL
(D-8) $ 90.00	$30.00	$11.00	$15.00	$50.00	$196.00
(D-9) $125.00	$30.00	$11.00	$15.00	$50.00	$231.00

Following are some recommended procedures for modifying either D-8 or D-9 tractor track rollers (Fig. 6).

Drill a hole and insert a pressure grease fitting in the center of the roller. Weld a protective guard over the grease fitting. This grease fitting greatly lengthens the life of the roller by permitting frequent lubrication. Lubricating the roller every four hours should be adequate under most conditions.

Weld collar to drum and spot weld all bolts so shafts cannot be pulled out.

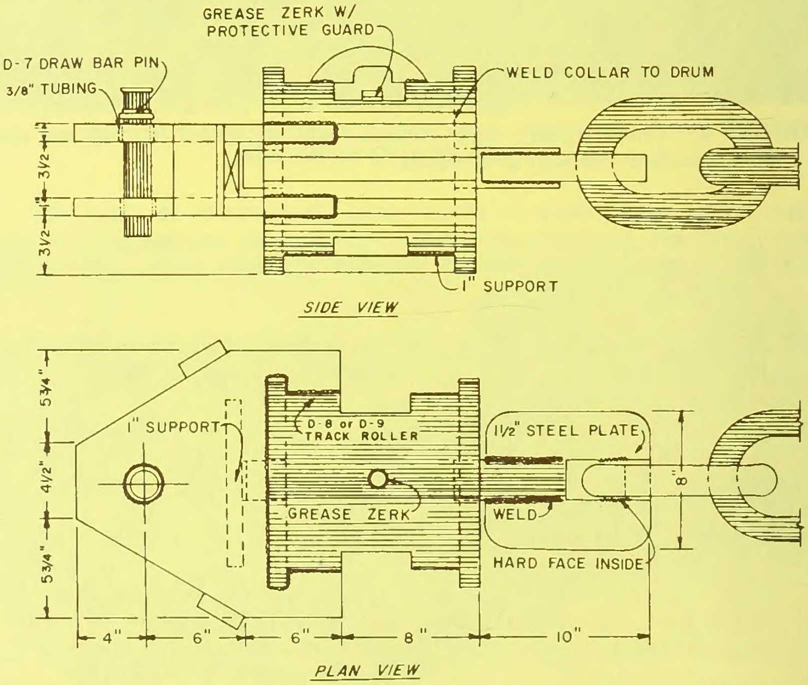

FIGURE 6 — Diagram showing procedures for modifying D-8 or D-9 tractor track rollers into anchor chain swivels.

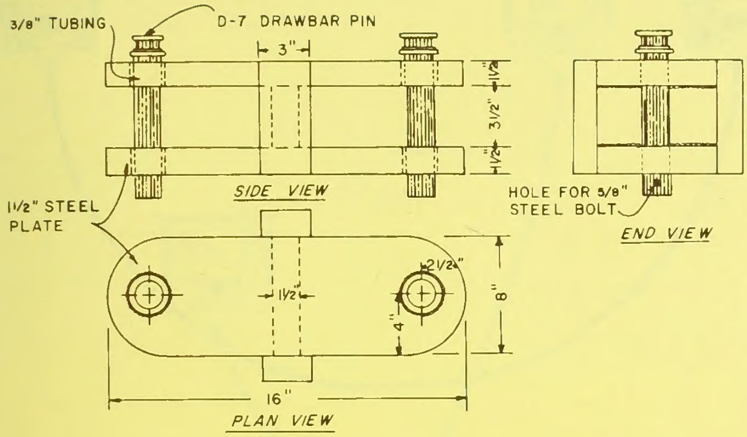

FIGURE 7 — Detailed drawing for making a connector link.

Weld two 1 1/2 inch steel plates to drum. Drill and hardsurface 3/8 inch hole for installation of a D-7 drawbar pin.

Weld a 1 1/2 inch plant to roller shaft for attachment to tractor. Attach a short length of anchor chain (approximately 15 feet of 40 pound per link chain) for easy hook-up to the tractor. This arrangement also allows the tractor driver space to back the tractor without damaging the swivel.

Apply hardsurfacing material to face of drum and protective guard to reduce wear, especially when swivel is used in rocky soils.

OPTIMUM LENGTH OF ELY CHAIN

For best results, the length of Ely chain should not exceed 210 feet when used in dense stands of pinyon-juniper; and 300 feet in open stands of pinyon-juniper and/or big sagebrush. These lengths are made up of 2 and 3-90 foot sections of Ely chain, respectively, with 15 foot lengths of light weight smooth chain on each end. Low tractor drawbar horsepower may necessitate shorter lengths.

For ease in reducing lengths of chain it is recommended that: (1) the chain be made in lengths of 90 feet, and (2) connector links be used to connect these lengths. The connector links can be made as shown in Figure 7.

TRACTOR HORSEPOWER REQUIREMENTS

Tractor horsepower needed to pull the Ely chain will vary according to the vegetative cover and terrain. Generally, about 200 drawbar horsepower should be specified when chaining pinyon-juniper, regardless of the terrain. In the big sagebrush type with flat terrain a minimum of 150 drawbar horsepower is required. Chaining the same vegetative type in steep terrain usually requires about 200 drawbar horsepower.

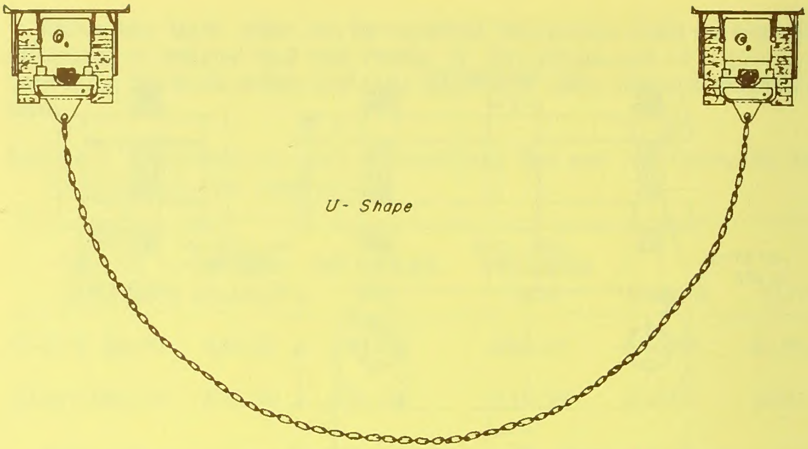

FIGURE 8 — Best results are achieved in closing and closed stands of pinyon-juniper by pulling the Ely chain in an open "U" shape.

These requirements initially may cost more per acre but in the long run will save money for the contractor and contracting agency by reducing the time required to complete the job. In addition, equipment in good working condition should be specified. Frequently the original drawbar horsepower of a piece of equipment might have been adequate, but worn equipment cannot produce its rated capacity.

BEST PATTERN FOR PULLING THE ELY CHAIN

The most effective pattern or shape for pulling the Ely chain will depend upon the type of vegetative cover and amount of vegetative removal desired.

Pinyon-juniper. In closing and closed stands (see page 14) of pinyon-juniper, the best results are achieved by pulling the Ely chain in an open "U" (Fig. 8). The distance between tractors will vary according to the length of chain, tractor horsepower, density of trees and terrain. Under conditions where tractor horsepower is adequate and moderately dense stands of pinyon-juniper on level terrain are being chained, tractors spaced approximately 100 feet apart can be expected to pull 210 feet of Ely chain.

For maximum results on invading stands of young pinyon-juniper (up to seven feet in height) the Ely chain should be pulled in the form of a "J" (Fig. 9). When pulled in this manner, the greatest amount of tree removal will occur along the straight portion of the chain while the least occurs in the loop.

Big Sagebrush. The degree of big sagebrush removal can be regulated easily by the pattern in which the Ely chain is pulled. By pulling the chain in the shape of a "J", maximum control of 70 to 85 percent will result from double chaining in opposite directions. The greatest amount

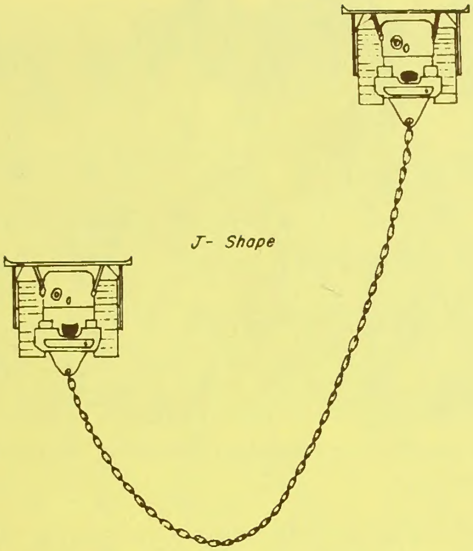

FIGURE 9 — When chaining invading stands of pinyon-juniper or big sagebrush best results are achieved by pulling the Ely chain in a "J" shape.

of removal will occur along the straight portion of the chain, while the least occurs in the loop. The number of big sagebrush plants removed is reduced as the chain is pulled in an open "U" shape. This may be desirable when chaining a big sagebrush-bitterbrush association, especially when low growth bitterbrush plants are present. It has been found that this type of bitterbrush plant escapes serious damage by the Ely chain when the chain is pulled in a "U" shape; whereas, up to 50 percent big sagebrush removal is achieved.

The amount of big sagebrush controlled also is greatly influenced by soil-moisture conditions and size of plants. Ideal conditions include moist soil and large robust plants.

The distance allowed between tractors will vary according to the length of Ely chain, terrain and configuration in which the chain is being pulled. When pulling 300 feet of Ely chain in a "J" shape over flat terrain, tractor spacing should normally be about 150 feet. Pulling the Ely chain in a "U" shape under similar conditions one could expect the tractor spacing to be about 200 feet.

CHARACTERISTICS OF THE ELY CHAIN

The characteristics of the Ely chain will vary with the type of vegetation being chained.

Pinyon-juniper Removal.

When chaining mature pinyon-juniper during the first pass, the rail on the Ely chain will cause a sawing action at the base of large trees as the chain is pulled forward. The rail will eventually hook the base of large trees and uproot them. The chain then rolls over the trees, crushing and breaking the branches. Heavier Ely chains have the advantage of crushing the trees much better than do the lighter chains. The Ely chain also pro-

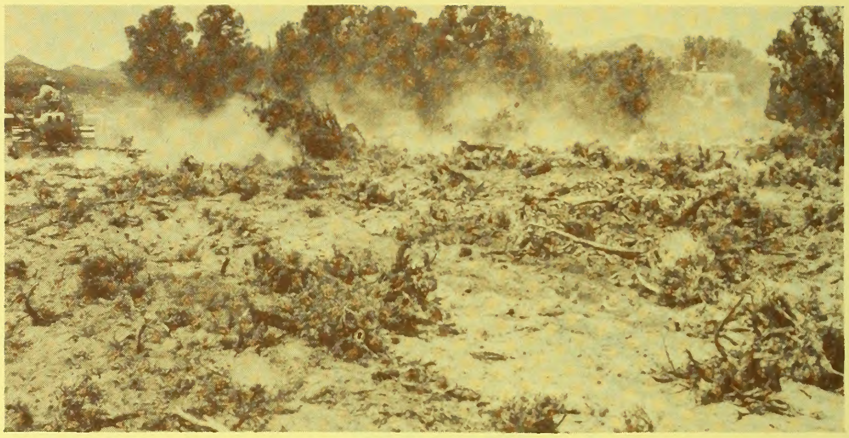

FIGURE 10 — Soil scarification caused by the rail creates an excellent seedbed for aerial seeding.

vides soil scarifying action as the rails till the soil (Fig 10). As a result of this tilling action, an excellent seedbed is prepared. This is particularly important in mature stands of pinyon-juniper where the soil surface is often covered by erosion pavement.

During the second chaining, which normally is done from the opposite direction from the first, the chain may cause the trees to pile and drag in front of it, stalling tractors of inadequate horsepower. When this happens, the tractor operators are forced to pull the chain around the pile of trees. This problem is largely eliminated by using tractors with a minimum of 200 drawbar horsepower which can maintain an operating speed sufficient to keep the chain revolving fast enough to free itself of accumulating trees. A third swivel attached in the middle of the chain helps to increase this rolling action. Pulling the chain in an open "U" shape also helps to control the piling effect; larger and heavier tractors are required to accomplish this pattern.

The piling of trees in front of the chain provides additional soil scarification and aids in covering seed. However, the larger piles of trees tend to cover seed too deeply. Small piles usually will cover seed to a sufficient depth. From this standpoint alone, it is extremely important that the piling effect be minimized.

Big Sagebrush Removal. When chaining during the first pass, ends of the rail cause an uprooting effect as the chain rolls in the direction of pull. Approximately 40 percent big sagebrush removal will occur during the first chaining. In addition, the rails will cause considerable soil scarification (Fig. 11). As a result of this scarifying action, an excellent seedbed is prepared for aerial seeding.

During the second chaining, normally from the opposite direction, the chain causes an additional 40 to 45 percent removal of big sagebrush. Excellent seed coverage is achieved by increased soil scarification during the second chaining. Ideal conditions are created for seeding with rangeland drills, if desired.

Another feature of the Ely chain is the ability of understory grasses and forbs to escape damage, even when chained-over twice. (Fig. 12).

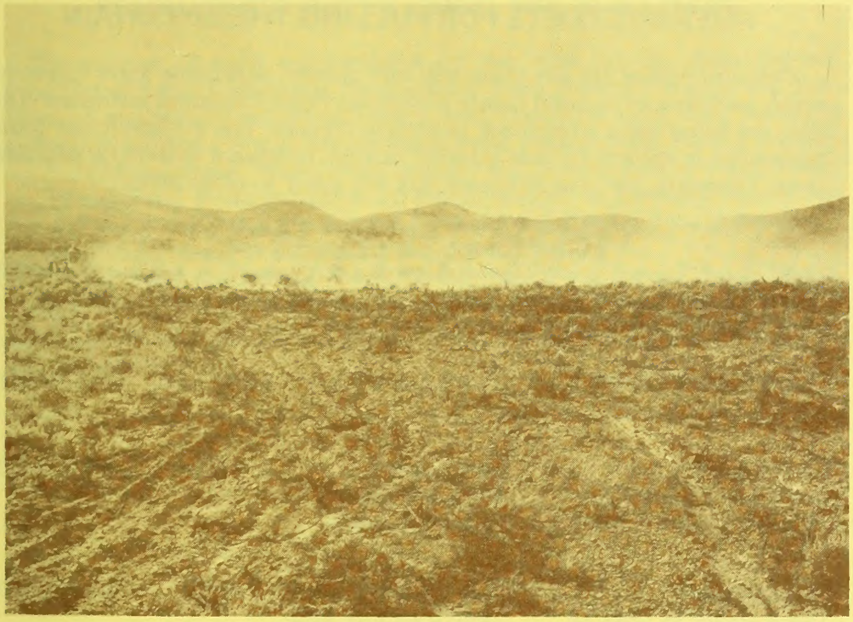

FIGURE 11 — Approximately 40 percent big sagebrush removal is achieved by the Ely chain during the first chaining. In addition, an excellent seedbed is prepared.

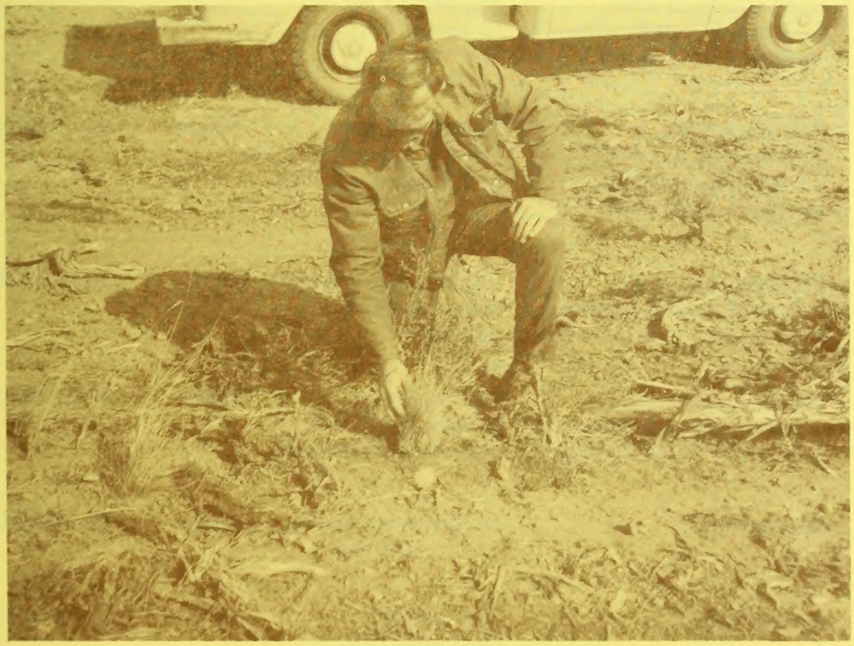

FIGURE 12 — Understory grasses frequently escape damage by the Ely chain.

AVERAGE COSTS FOR PULLING THE ELY CHAIN

Costs for pulling the Ely chain will vary greatly, depending upon vegetative cover, rockiness of soil and nature of terrain. Table 3 contains estimated costs that are based upon experience in eastern Nevada. The availability of heavy equipment in eastern Nevada is rather limited, compared with more populous areas. Therefore, the cost estimates may not apply to other areas.

TABLE 3 — Average costs for pulling the Ely chain in various vegetative types, soil conditions and terrain. Costs are based on double chaining.

VEGETATIVE TYPE	TERRAIN-SOIL	ACREAGE	COST/ACRE
Pinyon-juniper Dense stands of trees 18 or more feet in height	Steep terrain Deep soils with little or no rock	1000+	$6.00-$7.00
Pinyon-juniper Dense stands of trees 18 or more feet in height	Flat to rolling terrain, Deep soils with little or no rock	1000+	$5.00-$6.00
Pinyon-juniper Open stands of trees 7-18 feet in height with sagebrush understory	Steep terrain, Deep soils with little or no rock	1000+	$5.00-$6.00
Pinyon-juniper Open stands of trees 7-18 feet in height with sagebrush understory	Flat to rolling terrain, Deep soils with little or no rock	1000+	$4.00-$5.00
Big sagebrush with scattered pinyon-juniper trees up to 7 feet in height	Steep terrain, Deep soils with little or no rock	1000+	$3.00-$4.00
Big sagebrush with scattered pinyon-juniper trees up to 7 feet in height	Flat to rolling terrain, Deep soils with little or no rock	1000+	$2.00-$3.00
Big sagebrush	Rolling terrain with with rocky soils	1000+	$2.00-$3.00
Big sagebrush	Flat terrain Deep soils with no rock	1000+	$2.00-$2.50

PRODUCTION RATES USING THE ELY CHAIN

The amount of work accomplished per day with the Ely chain depends upon several factors, including the length of chain, drawbar horsepower, condition of equipment, nature of terrain, and vegetative type. The following production rates per 8-hour day are based upon experience in eastern Nevada.

Pinyon-juniper. When using tractors with a minimum of 200 drawbar horsepower, in dense stands of pinyon-juniper in moderate terrain, an average of 200 acres per day can be chained during the first chaining and about 150 acres per day during the second chaining.

Big Sagebrush. Using the same size tractors in big sagebrush and in flat to moderate terrain, one could expect to chain one way about 300-320 acres per day. This same rate also can be achieved during the second chaining.

Part II

Chaining Pinyon-Juniper and Big Sagebrush for Multiple-use Benefits

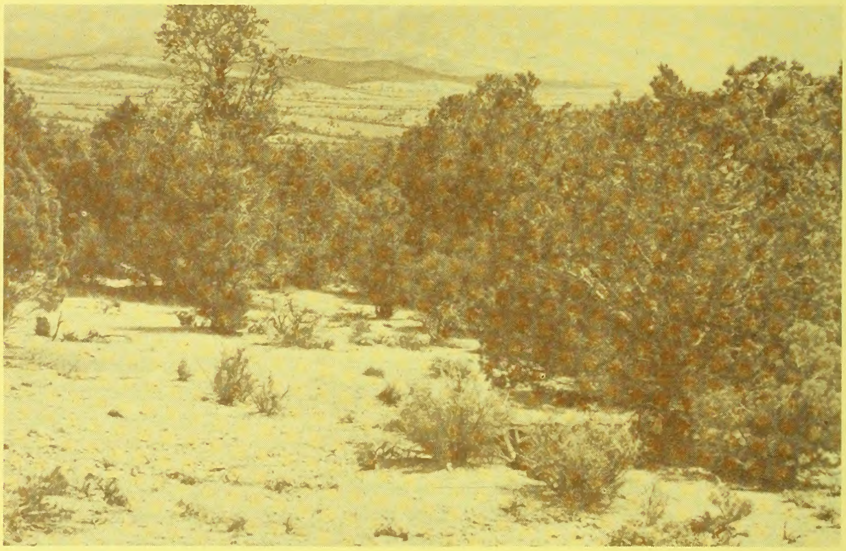

FIGURE 13. — A typical scene of a closed pinyon-juniper community.

PINYON-JUNIPER — A NEED FOR CHAINING

Approximately 60 million acres of land in the western United States are covered by communities of pinyon-juniper woodland. Studies by Blackburn (1960) in north and east-central Nevada indicate the presence of juniper as early as 1725, while pinyon was not present in any quantity before the 1800's. More recently, the extent of pinyon-juniper woodland in Nevada has increased substantially. Causes for this increase include overgrazing, drought, fire control, and the dispersal of seeds by animals (Blackburn, 1960).

For the purpose of this handbook, pinyon-juniper communities (Fig. 13) are placed in three broad types: invading, closing and closed. The invading communities are characterized by trees ranging in size from seedlings to saplings up to 7 feet in height. Typically, this community supports an understory of browse, grasses and forbs. The closing communities contain scattered pinyon-juniper that range from 7 to 18 feet in height. An understory of browse, grasses and forbs is usually present, but may be in poor condition. The closed communities are characterized by large, mature or decadent pinyon-juniper. Usually no understory is present. There is usually a concentration of litter around trees, and large interspaces are evident.

Generally, invading pinyon-juniper communities support an adequate understory of browse, grasses and forbs to provide quality ground cover, forage and cover for wildlife and forage for livestock. Control measures designed to eliminate competition from invading pinyon-juniper communities are generally not economically feasible and should be undertaken only under special conditions. Proper livestock management offers more economical methods for improving these communities.

In the closing and closed pinyon-juniper communities, the understory of desirable browse, grasses and forbs has been lost because of their inability to compete for nutrients, moisture and sunlight. This stage of plant succession has definite ecological effects which often are undesirable. Wildlife populations dependent upon the understory for food are declining. Public recreation values based upon these wildlife populations are, in turn, diminishing. Many acres of valuable grazing lands are deteriorating because of the extensive encroachment of pinyon-juniper. The lack of vegetative cover characteristic of the denser communities gives rise to run-off and erosion during high intensity storms. The result is frequent damage to the watershed, other resources and private lands.

MULTIPLE-USE BENEFITS FROM PINYON-JUNIPER CHAININGS

The manipulation of pinyon-juniper by chaining accomplishes the basic effect of setting back plant succession by controlling or eliminating the climax species and introducing other vegetative species or perpetuating native plants. The consequence is restoration of pinyon-juniper invaded rangelands for increased livestock forage, watershed cover, water production and forage and cover for wildlife. To achieve multiple-use benefits, it is imperative that a variety of plant species be established, either naturally occurring species or introduced species.

In many areas, the practice of converting rangelands covered with closing or closed stands of pinyon-juniper to a mixture of browse, grass and forbs results in the following multiple-use benefits:

(1) increased grazing capacities, as high as 3 acres per cow month;
(2) improved watershed conditions by changing vegetative cover from a canopy cover to a more desirable basal cover and increasing ground litter. The presence of debris also aids in protecting the watershed by slowing overland flow during high intensity summer storms;
(3) increased water yield, up to an estimated 0.60 of an inch annually (Cortner, 1963); and
(4) improved wildlife habitat by establishing an assortment of plant species needed to provide a variety of nourishment on a yearlong basis.

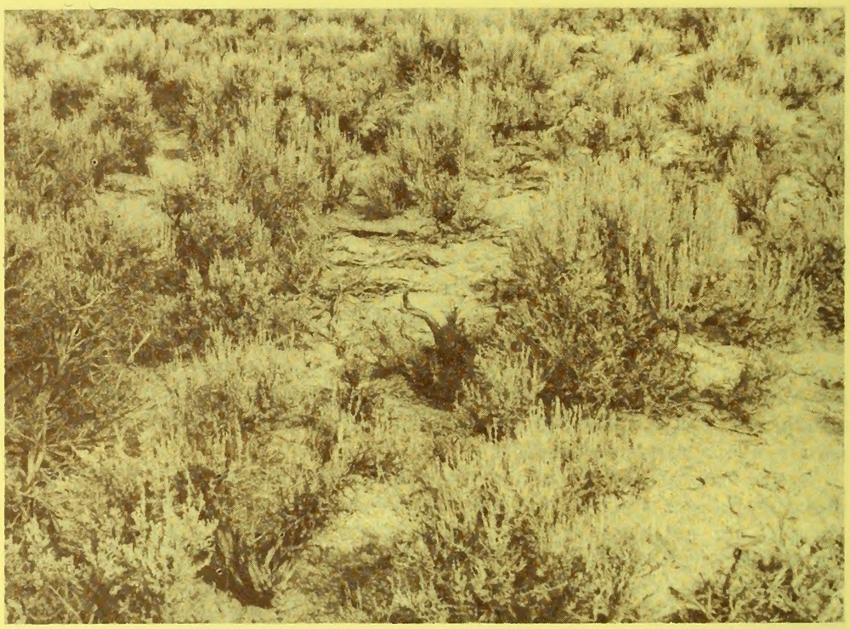

FIGURE 14. — A typical big sagebrush community.

BIG SAGEBRUSH – A NEED FOR CHAINING

Over 270 million acres of sagebrush rangeland occur in the western United States; approximately 146 million acres are covered by big sagebrush (Beetle, 1960). Big sagebrush grows on low foothill ranges, adjacent valley floors, in mountain brush and aspen associations, and in subalpine zones at elevations above 10,000 feet. It is associated with blackbrush and creosotebush in the southern desert shrub types (Plummer, Christensen and Monsen, 1968).

Big sagebrush is generally a climax species which has the ability to invade contiguous plant associations such as grassland, desert shrub, chaparral and woodland (Oosting, 1956). Overgrazing has been a major contributor to the success of sagebrush invasion. As a result, numerous areas which originally supported pure grass types have converted to the sagebrush climax. Under the natural conditions of climate and soil now existing on semiarid ranges, big sagebrush will maintain itself indefinitely as climax vegetation.

Dense stands of big sagebrush have definite undesirable effects by using moisture and nutrients needed for the growth of desirable understory plants. Consequently, the desirable plants are of such low vigor that they provide little or no value for livestock or wildlife forage or watershed protection. In many areas the understory is lacking. The consequence is a low grazing capacity for livestock. In addition, a lack of ground cover provided by grasses gives rise to run-off and erosion during high intensity storms.

The presence of big sagebrush is not always undesirable. Certain wildlife species, including deer, elk and pronghorn antelope rely upon big sagebrush as an important source of food during the winter season, especially if other browse plants are lacking. Big sagebrush also provides essential food, nesting and brood cover for sage grouse. Many workers attribute the decline of sage grouse populations to the thoughtless eradication of big sagebrush throughout the western United States.

For the purpose of this handbook, big sagebrush communities are categorized into three broad conditions (Fig.14).

(1) dense stands of big sagebrush supporting an understory of desirable plants;
(2) dense stands of big sagebrush lacking an understory of desirable plants; and
(3) big sagebrush associated with other browse species.

Dense stands of big sagebrush supporting an understory of desirable plants offer an opportunity for improvement through the use of two methods. The first method involves the use of some grazing system to increase vigor, reproduction, and seedling establishment of the desirable plant species. The second method requires the removal of sufficient competition for release of the native understory by appropriate methods, followed by grazing management. The removal of big sagebrush plants may be warranted if:

(1) the density of plants restricts livestock movement;
(2) a more rapid response is needed than can be achieved through grazing management alone; and
(3) partial removal of big sagebrush will improve wildlife habitat.

Part III

Aesthetics and Pinyon-Juniper Chainings

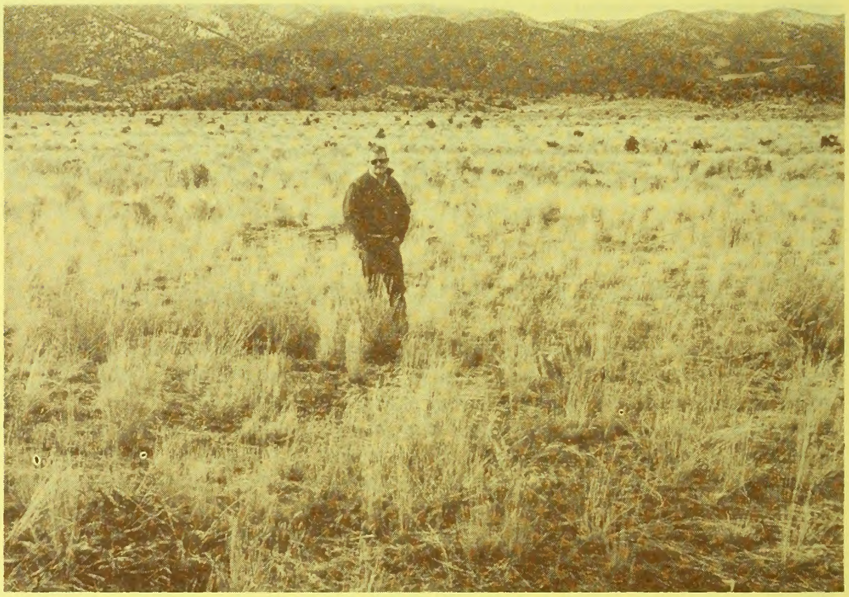

FIGURE 15 — The Ely chain adequately reduces competition for the response of: A. native understory grasses and forbs; and B. introduced grasses and forbs.

Where an understory of desirable plants is absent, it is necessary to remove all or part of the competition by an appropriate method. Reseeding is desirable where less than one-fifth of the total plant cover is composed of desirable plants.

Big sagebrush-browse associations offer an excellent opportunity for improvement through grazing management, particularly where decadent browse species offer little or no value for livestock or big game forage. Unfortunately, the importance of livestock grazing, especially by cattle, as a means of restoring these plants is too often not clearly understood. When manipulating the big sagebrush-browse communities, extreme care must be taken to preserve the browse species. Failure to do so will destroy their value as wildlife habitat.

MULTIPLE-USE BENEFITS FROM BIG SAGEBRUSH CHAINING

Partial control of big sagebrush such as that achieved by the Ely chain offers an excellent means of restoring depleted rangelands for multiple-use purposes. To achieve these multiple-uses, it is essential that sufficient competition be removed to enable native grasses, browse and forbs to respond, or to permit introduced grasses, browse and forbs to establish themselves. It is essential that enough big sagebrush plants survive chaining to provide food and cover for wildlife.

In eastern Nevada, removal of 70 to 85 percent big sagebrush plants by the Ely chain adequately reduced competition for the response of native understory grasses and forbs, and introduced plants (Fig. 15). As a result, the following multiple-use benefits are being realized:

(1) conversion of rangelands with a grazing capacity of 30 to 50 acres per cow month into more productive rangelands with a grazing capacity of 3 to 6 acres per cow month;

(2) increased watershed cover by converting the vegetative cover from a canopy cover to a more desirable basal cover, and increasing ground litter;

(3) improvement of wildlife habitat by establishing an assortment of plant species needed to provide a variety in nourishment on a yearlong basis, while still maintaining adequate cover. Big sagebrush plants remaining after chaining are a necessary component in this community. Wildlife species benefiting from this treatment include, but are not limited to: deer, pronghorn antelope, sage grouse, and small non-game birds and mammals.

This method of manipulating big sagebrush is not to be considered a cure-all means of restoring depleted rangelands. Instead, it accomplishes the effect of setting back plant succession by controlling the climax, or invader species, and by allowing the establishment of other vegetative species, namely grasses and forbs. It does, however, have the disadvantage of creating a condition favorable to the re-invasion of big sagebrush, especially if improper grazing management follows or the site is primarily adapted to big sagebrush. Proper livestock grazing management may retard the re-invasion of big sagebrush enough to realize long term benefits. The important factor to consider is that these benefits are multiple-use, not single use.

ADVERSE VISUAL IMPACT OF PINYON-JUNIPER CHAININGS

During the past two decades many aesthetically pleasing landscapes have been scarred by poorly designed vegetative manipulation projects. As more attention is directed toward protection of the environment, a greater awareness must be recognized of the need to plan and design all vegetative manipulation practices to minimize adverse effects on the landscape.

Pinyon-juniper chainings have the greatest potential of all rangeland vegetative manipulation practices for creating unpleasant views of the landscape. This is particularly evident where contrasts between treated and untreated areas are accentuated by large open spaces with more or less symmetrical boundaries

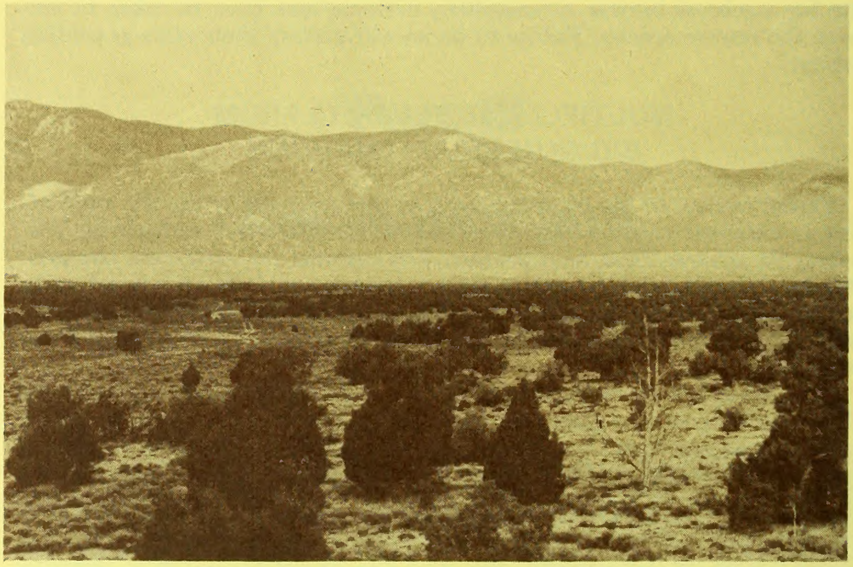

FIGURE 16 — Contrasts between treated and untreated pinyon-juniper types are accentuated by large open spaces.

(Fig. 16). The visual impact of such treatments is similar in many respects to clear-cut timber harvesting (Barnes, 1969). Sagebrush manipulation practices usually create a less pronounced visual impact upon the landscape primarily because of a softer color expressed by the vegetation. Nevertheless, in certain situations poorly designed sagebrush manipulation practices will disturb the natural appearance of a landscape (Fig. 17).

SOME DESIGN METHODS FOR LANDSCAPING WITH PINYON-JUNIPER CHAININGS

Because pinyon-juniper chainings create the greatest problem in disturbing the scenic aspect of a landscape, a discussion on methods of design will be confined to the pinyon-juniper type. However, the basic principles discussed should apply to other vegetative types as well as other treatment methods.

When planning and designing pinyon-juniper chainings general or distant views and close-up views of the treatment site should be considered. It also is helpful to view the proposed treatment area from all angles, including aerial observations. The designer is encouraged to use his imagination and be creative. A landscape architect should provide expertise in designing pinyon-juniper chainings.

Unpleasant general views of the landscape where pinyon-juniper has been manipulated are frequently caused by drastic changes in color resulting from the removal of trees. For that reason, it is necessary that pinyon-juniper chainings be designed to simulate natural openings in the landscape. Several methods of design can be used to simulate such a natural appearance.

Starting the removal of pinyon-juniper at the edge of a transition zone with other vegetation, such as sagebrush, creates an appearance that the sagebrush

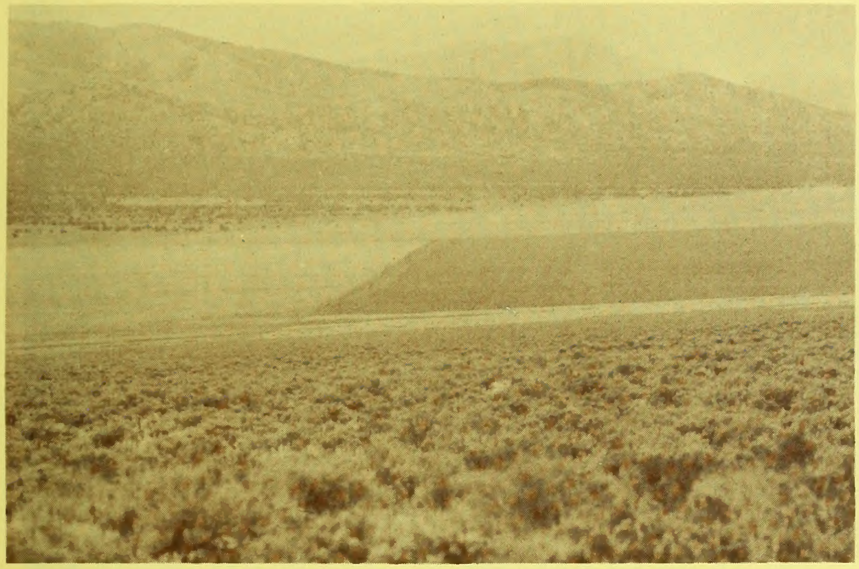

FIGURE 17 — Poorly designed sagebrush manipulation practices can disturb the natural appearance of a landscape.

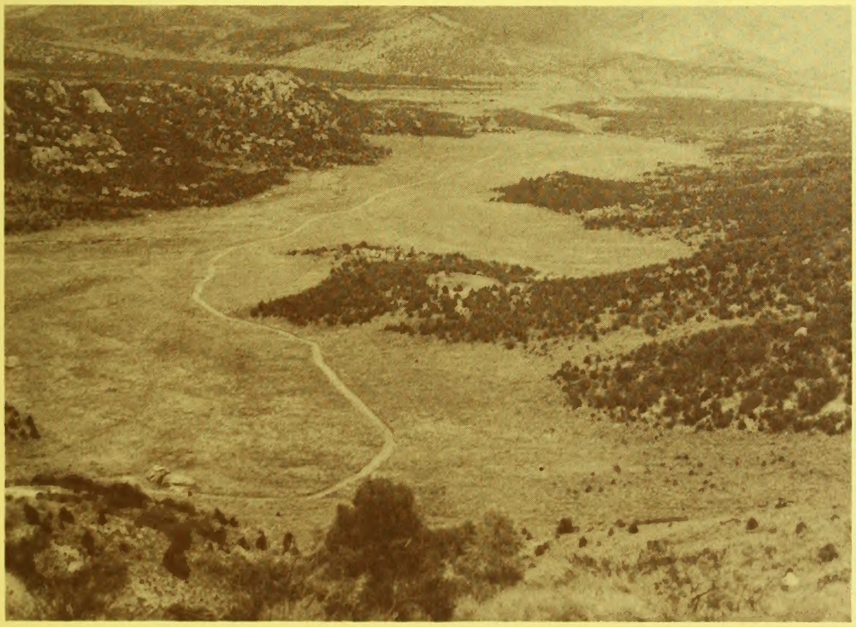

FIGURE 18 — Leaving fingers or islands of unchained trees is helpful to simulate natural openings in the landscape.

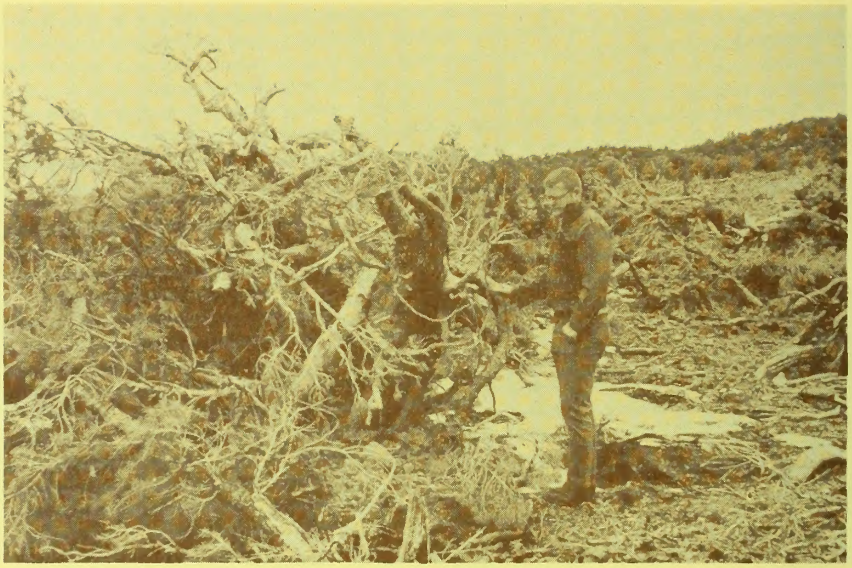

FIGURE 19 *— The presence of scattered debris remaining after pinyon-juniper chainings are cause of an unpleasant close-up view.*

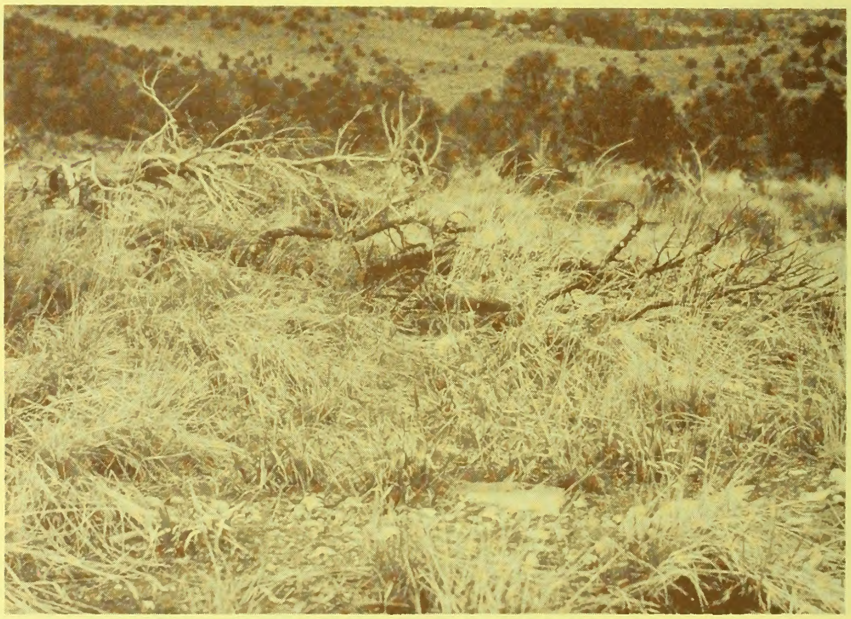

FIGURE 20 *— Establishing tall grasses helps obscure the view of debris remaining after the chaining treatment.*

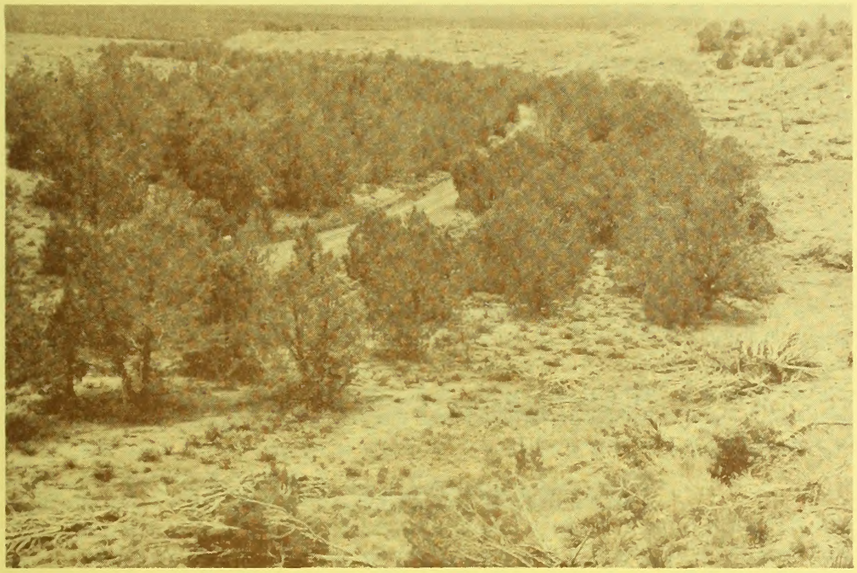

FIGURE 21 — Unchained strips of trees along roads and trails provide an effective means of reducing the visual impact of pinyon-juniper chainings.

type extends into the pinyon-juniper type. To accomplish this, irregular boundaries and relatively small openings must be maintained.

The study of natural openings in existing vegetative types offers good examples how pinyon-juniper chainings can be designed to simulate nature. Here again, small openings and irregular boundaries are essential to achieve this natural appearance (Fig. 18).

Leaving fingers or islands of unchained trees provides means whereby open spaces created by chainings can be blended into the landscape. Topographic features are helpful in selecting areas in which unchained trees should be left.

Close-up views of pinyon-juniper chainings are usually made unpleasant by the presence of scattered debris remaining after the chaining treatment (Fig. 19). The adverse visual impact of such sights can be eliminated or reduced by several methods.

Windrowing and burning the debris is frequently done to remove unsightly debris from chained areas. However, this practice is often considered undesirable because piles of debris left after chaining offer excellent cover for wildlife and watershed protection. In addition, it is often considered too expensive for use on low production rangelands.

When debris is left in a chained area, it may be desirable to burn or break-up and scatter the debris. A subsequent stand of tall grasses helps to obscure the view of debris and give color to chained sites (Fig. 20).

Another effective means of reducing the visual impact of pinyon-juniper chainings is to leave strips of unchained trees along roads and trails as scenic corridors (Fig. 21). The most effective width of such strips will depend upon the height and density of standing trees and topography.

Maintaining buffer zones around recreation sites, archeological and historical sites also helps to screen the adverse visual impact of pinyon-juniper chainings. Such buffer zones offer an excellent means of preserving the sites.

Part IV

Suggested Principles and Procedures for Successful Range Restoration Work

INTRODUCTION

The success of range restoration work involving anchor chaining, other mechanical methods and chemical treatments largely depends upon the recognition and use of certain principles and procedures. Several of these have been demonstrated by the U. S. Forest Service and Utah Department of Fish and Game at the Great Basin Experimental Area in Ephraim, Utah (Plummer, Christensen and Monsen, 1968); others have been tested by the Bureau of Land Management in eastern Nevada (Cain and Hammersmark, 1969). They are divided into three categories: pre-treatment, treatment and post-treatment.

I. Pre-Treatment

   A. Determine Objectives.

   During the initial planning stage, objectives of the treatment should be determined. Usually, these objectives will identify needs for an increase in forage for livestock and wildlife or plant cover for watershed improvement. It is imperative that those objectives involving wildlife habitat be closely coordinated with State Fish and Game personnel.

   Due consideration should be given to designing treatments that will serve multiple-use purposes. In most situations, wildlife, livestock and watershed needs can be met through a single, properly planned treatment measure. Only on rare occasions should a treatment be designed to serve one purpose.

   B. Determine if a Change in Plant Cover or Composition is Desirable.

   The objective of range restoration work is to strive for the production of optimum quantity of desirable vegetation to meet various resource demands. First, it must be determined if the present plant cover or composition is sufficient to satisfy these demands or if a change is needed or desirable. In making this decision, it should be kept in mind that the real key to successful range restoration work is the ultimate production of a variety of plant species that will provide for multiple-use of the land.

C. Determine Best Means of Attaining Change in Plant Cover.
It is strongly suggested that the first consideration be given to the use of grazing management as a tool in bringing about a desired change in plant cover and/or composition. This can best be accomplished through livestock grazing management. If this is not feasible, a reduction in plant competition by appropriate means may be necessary.

Eradication of most undesirable species is not always desirable. For example, complete removal of big sagebrush may have a detrimental effect upon wildlife habitat. For that reason care must be exercised to insure that treatments specifying total big sagebrush eradication be located and designed to minimize damage to the wildlife habitat. Complete control of pinyon-juniper is possible only through the combination of several types of treatment. However, the cost is usually expensive. Such treatments should be confined to special areas. The most efficient and economical method should be used for optimum control of pinyon-juniper.

D. Select Soil Types Most Suitable for Treatment.
An analysis of soil taken from proposed treatment areas will aid in the determination of the nature and potential productivity of the soils in a proposed treatment area. These findings are also useful in selecting plant species best suited to the soils.

Where possible, the best sites should be selected for treatment first. Improvement may be possible on less suitable sites, but similar effort on more favorable sites would be preferable because the response of seeded or native species would be more rapid. In certain areas, less desirable sites will require treatment because of a need for vegetative cover to control erosion. In this case, forage for wildlife and livestock production may be a secondary consideration. Nevertheless, these uses should be considered.

E. Determine if Precipitation is Adequate.
The annual precipitation rate is often the most important factor leading to the success or failure of range restoration work. Therefore, it is important to choose sites that receive adequate annual precipitation, which should normally exceed nine inches.

Rain gauges placed near proposed treatment areas well in advance of the actual treatment will aid in determining if precipitation is adequate.

The presence of indicator plants is important in deciding if precipitation is adequate in a proposed treatment area. The occurrence of pinyon-juniper usually indicates favorable sites. Vigorous big sagebrush plants are good indicators. The complete absence of pinyon-juniper, mountain brush, and vigorous big sagebrush plants generally indicates a site too dry for treatment. An abundance of halophytes usually represents a dry site.

F. Determine Plant Species Suited to Proposed Treatment Area.
Plant species to be seeded must be suited to the proposed treatment site. Soils and precipitation data gathered in advance should be used to select suitable plant species.

Generally speaking, seed sources having different soils or climatic conditions are less likely to produce good stands than seed from sites similar to those where it will be planted. Seed of browse species, especially bitterbrush should be planted in the same environment as its source for any degree of success.

Since browse seed frequently is purchased from commercial seed collectors, it is desirable to specify that bitterbrush seed be collected from a particular elevation, precipitation belt and soil type.

G. Determine if a Seed Mixture is Desirable.

Planting of seed mixtures is desirable where multiple-use benefits are involved with range restoration work. The success of range restoration work depends heavily upon their use. The reasons are:

1. They are better suited to varied soil, terrain, and climatic conditions. Several species in a mixture take advantage of these conditions, and eventually the best suited species will prevail.
2. Mixtures usually provide a variety in nourishment that is desirable to both livestock and game animals.
3. Where a variety of species is represented, the roots penetrate to various depths. Some utilize surface moisture, others use that from deeper levels, still others may use both shallow and deep moisture. The deeper rooted plants may continue active growth for some time after the surface moisture has been exhausted. The somewhat deeper-rooted perennial grasses continue growing longer until the moisture in their root zone has been depleted. The shrubs, with their still deeper roots, may continue active growth for a much longer period.
4. Mixtures produce better ground cover than single species.
5. Certain species are sufficiently shade-tolerant and competitive with dwarf oak and other thicket-growing brush and can reduce their growth to a height where game can reach the foliage.
6. Certain species included in mixtures may have favorable influences on others; a noteworthy example is the nitrification accomplished by legumes.
7. Rapidly developing species provide needed forage during the establishment of slower species.

H. Determine Extent of Rodent Population.

In eastern Nevada, a cooperative study with the U. S. Bureau of Sport Fisheries and Wildlife in July and September, 1969, showed a rodent population of 46 and 48, based upon a 100 trap nights, in a closed stand of pinyon-juniper. A rodent population of this density is capable of digging up and destroying bitterbrush seed included in seed mixtures. Actually, a rodent population exceeding 5 percent is capable of causing considerable damage to bitterbrush seedings, especially in view of the considerable expense of obtaining browse seed. It is speculated that many unsuccessful browse seedings are the result of a failure to identify damaging rodent populations and appropriate control action.

According to the U. S. Bureau of Sport Fisheries and Wildlife, the actual rodent population determines when control measures are required. Usually the following criteria are adequate in determining when control is necessary.

1. A rodent population less than 5 percent, based upon 100 trap nights, does not warrant control measures.
2. Rodent populations over 5 percent, based upon 100 trap nights, demand intensive rodent control measures to insure protection of planted seed.

A variety of rodenticides provide effective means of controlling rodents. However, certain rodenticides are believed to cause unnecessary, avoidable, or excessive hazards to man or the natural environment. Therefore, only rodenticides approved by the Environmental Quality Council (established by the National Environmental Policy Act of 1969) should be used.

I. Use Available Knowledge

Considerable work has been published on range restoration work. One of the best publications to date is "Restoring Big Game Range in Utah," by A. Perry Plummer and associates. Those concerned with range restoration practices are encouraged to take advantage of this knowledge and experience.

J. Inform the Public.

The importance of informing the public of range restoration work, particularly that involving wildlife habitat, cannot be over-emphasized. The proposed treatments should be publicized by local news media and by personal contact with sportsmen's groups and other interested parties. A field trip to the proposed treatment area during the early planning stages should be arranged to include all interested persons and agencies.

II. Treatment

A. Use Proper Methods and Equipment.

Employing proper methods or equipment in range restoration work is important. Careful consideration of the pre-treatment principles and procedures will aid in selecting appropriate methods and equipment. Following are descriptions and evaluations of some methods and types of equipment (Yoakum and Dasmann, 1969).

1. Grazing Management. Where sufficient potential remains for natural response of native plant species, proper grazing management can be a highly effective tool. In this situation, some livestock grazing system should be employed, rather than using costly chemical or mechanical treatments. The point of range depletion at which chemical or mechanical treatment should be undertaken must receive considerable thought.
2. Chemical Treatment. Such chemicals as 2, 4-D and 2, 4, 5-T are effective in controlling big sagebrush and other undesirable shrubs and forbs. Only those herbicides approved by the Environmental Quality Council should be used.

   The use of chemicals for big sagebrush control usually is designed to achieve maximum kill. Where important wildlife habitat is present, this may not be desirable. For that reason, some method of obtaining partial kill of big sagebrush should be used in the place of the application of chemicals.
3. Discing and Plowing. Another method of achieving maximum control of big sagebrush involves the use of heavy discs of brushland plows. This method of sagebrush eradication is the most common used to date. However, because of the apparent effects of near total big sagebrush eradication on wildlife habitat, it is expected that other methods, whereby partial control is obtained, will become equally important.
4. Anchor Chaining. Anchor chains provide a worthwhile means of reducing competition from pinyon-juniper and big sagebrush. When selecting anchor chains for use under various conditions, considera-

tion must be given to the size and type best suited to accomplish the desired results.

5. Cabling. Steel cables one and one-half inch in diameter have been used for removing competition from pinyon-juniper in the same manner as anchor chains. Cabling is less effective than anchor chaining because it does not eliminate young, flexible pinyon-juniper trees. However, it has the advantage of leaving a desirable understory undamaged. Cabling sagebrush is not satisfactory.
6. Bulldozing. Bulldozing has been used to eliminate scattered patches of trees without damaging associated plant species. It is also used to pile slash for burning after chaining. Generally, bulldozing is expensive and should be confined to special area.

B. Remove Sufficient Competition.

Complete elimination of competing plants is not always necessary, but they must be thinned enough to minimize direct competition for moisture and sunlight. The amount of competition removed will depend largely upon the objectives of the treatment.

C. Plant Sufficient Amounts of Seed.

A sufficient quantity of seed must be planted to insure establishment of good stands. Experience in eastern Nevada shows that five pounds viable seed per acre is adequate when drilling. At least twelve pounds viable seed per acre is advisable when aerial seeding in pinyon-juniper, and 7 pounds per acre when aerial seeding in big sagebrush. When seeding poor sites, the amount of seed should be increased. It is important to increase seeding rates when the purity and germination of the seed is low.

Special attention should be given when planting expensive seed. It may be desirable to hand plant expensive or scarce seed, or use a seed dribbler mounted over the tracks of track laying equipment.

D. Sufficiently Cover Seed.

Seed of most plant species should not be planted to a depth of more than one-fourth to one-half inch. Covering seed more than one-half inch deep tends to reduce emergence. Leaving seed uncovered after broadcasting is also unsatisfactory.

E. Plant in Proper Season.

Seeding most plant species as late in the fall as possible gives the best results. Seeding too early in the fall may result in precocious germination of certain species during periods of warm temperature. Spring plantings have occasionally been successful; however, they are not recommended as a standard practice.

F. Consider Aesthetic Values.

The sight of pinyon-juniper treatment areas is not appealing to most people. Therefore, every attempt must be made to develop scenic aspects.

G. Consider Cover for Wildlife.

Providing escape cover for wildlife in pinyon-juniper treatment areas is of utmost importance. Research has shown that a good habitat requires a close interspersion of food and cover. Cover should be left within about one-fourth mile of any part of a pinyon-juniper treatment area. The procedures described for maintaining aesthetic aspects are usually sufficient to insure adequate wildlife cover.

III. Post-Treatment.

A. Defer Use on Treated Areas.

Seedlings and young plants require protection from grazing and trampling by livestock, big game, rabbits and rodents to become established.

At least two full years protection from livestock grazing is suggested for most seeded species. Where forb and browse species are seeded, three full years is recommended. Since regulating big game animals may not be practicable, the size of a treatment area should be large enough to minimize big game concentration. Usually 300 acre areas are satisfactory.

Control measures may be required to reduce seedling damage and destruction by rabbits, rodents, and insects. The appropriate agency responsible for rodent or pest control should be contacted for professional guidance.

B. Do Not Overgraze Treated Areas.

Most range restoration work involving chemical or mechanical methods is costly. Therefore, it is important to protect the investment and realize the maximum allowable production from a treated area.

Livestock grazing on all treated areas should be closely regulated. When grazing livestock in treated areas designed to provide forage for livestock and big game, consideration must be given to leaving adequate forage to meet big game needs. Summer cattle use may damage succulent browse species needed as a reserve for fall and winter by big game. For that reason, it may be desirable to graze such areas on a rotation system, or early spring grazing.

Grazing on most treated areas is an important tool for manipulating grass-browse relationships. Grazing should remain flexible enough to maintain the desired balance of grass and browse species. After seeded species are well established, proper stocking by all grazing and browsing animals is the key to stand permanence.

C. Inform the Public.

Range restoration work easily accessible to the public should be identified with an information sign. It may be desirable to use a sign as a means of telling a story about the treatment and benefits expected to be derived.

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